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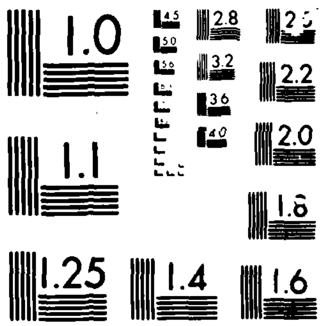
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CONCEPT DEVELOPMENT
COST ESTIMATES for

DIEGO GARCIA POL MOORING
ISLAND INSTALLATION

26 MARCH 1979

Ocean Engineering

CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON NAVY YARD
WASHINGTON, DC 20374

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The Ocean Engineering and Construction Project Office (FPO-1) of Chesapeake Division Naval Facilities Engineering Command (CHESNAVFACENGCOM) was tasked by Pacific Division Naval Facilities Engineering Command (PACNAVFACENGCOM) to perform a study of viable concepts for the installation of mooring (Con't)

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island dolphins at Diego Garcia, Chagos Archipelago, B.I.O.T. The six following concepts were analyzed for their relatively safe and economical constructability by Naval Construction Forces on the island:

Crawler Crane with Additional Bents
Direct Pile Driving from Work Barge
Jack-up AMMI Pontoon
Construction Jacket
Semi-Submersible Templet
Flexifloats

The analysis concluded that the construction jacket would be the best one since it provided the highest constructability by SEABEE/Underwater Construction Ream. PACDIV and OICC Pier Team, Diego Garcia, concurred with this conclusion and requested continuation of CHESDIV's effort into final design, plans, and specifications.

The estimated construction jacket weighs 43 tons per jacket. The FPO-1 engineering efforts are estimated to be $70,800 which includes the concept development, engineering analysis and design, drawings and specifications and 3 weeks on-site consultation. The in-house design work will be complete in 8 (earliest) to 16 weeks (latest).

FPO-1EA21:bo
26 March 1979

MEMORANDUM

From: FPO-1EA21
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Subj: Diego Garcia POL Pier Mooring Island Pile Driving Templets

Encl: (1) Concept Development and Cost Estimate for POL Pier Mooring Island Installation, Diego Garcia, Chagos Archipelago

1. Enclosure (1) is forwarded for information on the subject project.

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CONCEPT DEVELOPMENT AND COST ESTIMATE

FOR

POL PIER MOORING ISLAND INSTALLATION

DIEGO GARCIA, CHAGOS ARCHIPELAGO

BY

C. CHERN

SEPTEMBER 1978

REVISED JANUARY 1979

APPROVED BY: S.C. LING, Manager
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Design Division

OCEAN ENGINEERING AND CONSTRUCTION PROJECT OFFICE
CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON NAVY YARD
WASHINGTON, DC 20374

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EXECUTIVE SUMMARY

The Ocean Engineering and Construction Project Office (FPO-1) of Chesapeake Division Naval Facilities Engineering Command (CHESNAVFACENGCOM) was tasked by Pacific Division Naval Facilities Engineering Command (PACNAVFACENGCOM) to perform a study of viable concepts for the installation of mooring island dolphins at Diego Garcia, Chagos Archipelago, B.I.O.T. The six following concepts were analyzed for their relatively safe and economical constructability by Naval Construction Forces on the island:

- Crawler Crane with Additional Bents,
- Direct Pile Driving from Work Barge,
- Jack-up AMMI Pontoon,
- Construction Jacket,
- Semi-Submersible Templet,
- Flexifloats.

The analysis concluded that the construction jacket would be the best one since it provided the highest constructability by SEABEE/Underwater Construction Team. PACDIV and OIC Pier Team, Diego Garcia, concurred with this conclusion and requested continuation of CHESDIV's effort into final design, plans, and specifications.

The estimated construction jacket weighs 43 tons per jacket. The FPO-1 engineering efforts are estimated to be $70,800 which includes the concept development, engineering analysis and design, drawings and specifications and 3 weeks on-site consultation. The in-house design work will be completed in 8 (earliest) to 16 weeks (latest).

FIGURES

CHART

1. INTRODUCTION

1.1 Background

The U.S. Navy Construction Force is currently undertaking a Naval Support Facilities Project at Diego Garcia - One of the five islands in Chagos Archipelago. The Petroleum-Oil Lubricant (POL) Pier is one of the major facilities in this construction project. The pier mainly consists of a 1,150 feet approach trestle, a 560 feet by 40 feet main platform and two mooring islands. Figure 1.1 shows the key plan of the POL pier system. The mooring islands are located 175 feet away from the edge of the main platform and 60 feet setback from the docking face of the pier. The plan and the elevation of the mooring island are shown in figure 1.2.

The mooring island will be located at approximately 60 feet water depth and supported by a group of steel pilings. The group consists of 13 vertical and 16 batter piles at 1 to 3 slope. All pilings are 16 inches outside diameter and 0.344 inch wall thickness. The mooring islands are planned to be installed in May-July, 1979 period. One of the reasons is the favorable construction weather window. It appears that the sea states in this period are most favorable for the installation of pilings under open sea environment.

In August, 1978, CDR L. Donovan, Project Officer - Diego Garcia (Code 09DG), conferred with LCDR J. Stamm and the supporting staff of the Ocean Engineering and Construction Project Office (Code FPO-1), CHESNAVFACENGCOM, for developing concepts to install the mooring island in an efficient and economical way. In addition, the installation procedures have to be safe for the SEABEE operation. In early September, 1978, LT. J. Wong,

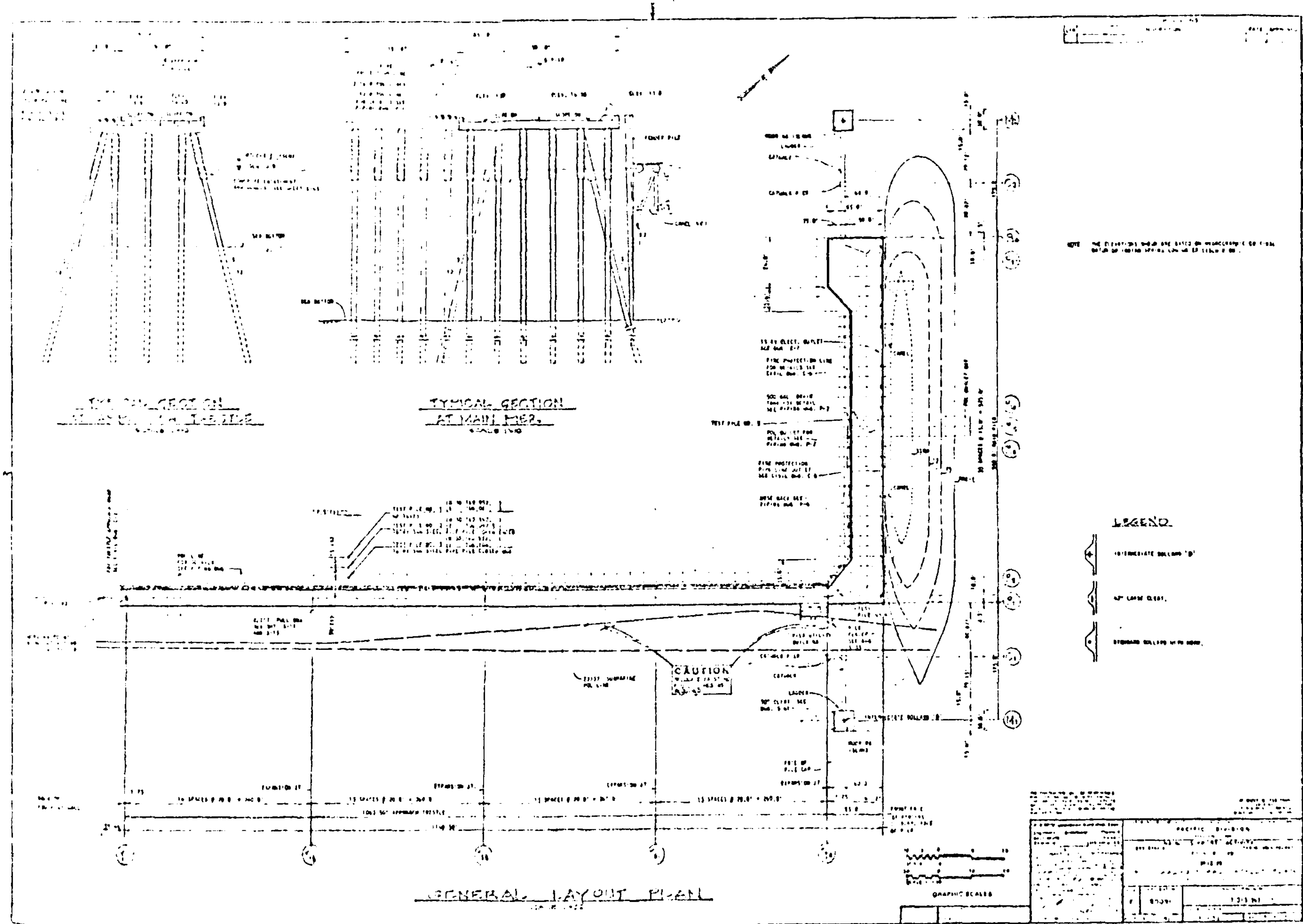


Figure 1.1 POL Pier General Layout Plan

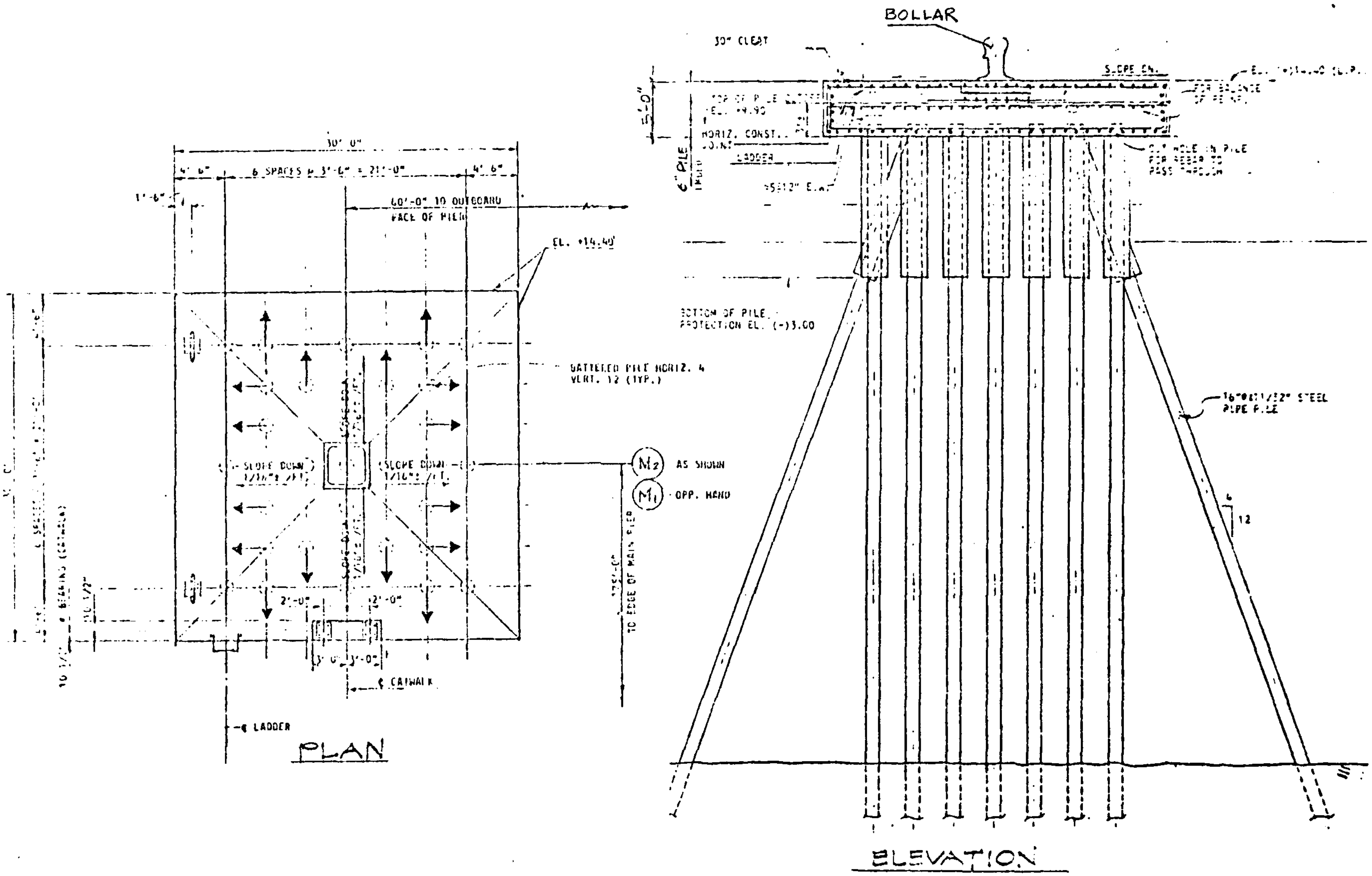


Figure 1.2 Plan & Elevation -- Mooring Island

OIC, Pier Team of Diego Garcia met with the FPO-1 personnel for further study of the concept development. During meetings with LT Wond, FPO-1 presented the following 5 concepts for discussion. These concepts were constrained to utilize the existing SEABEE/UCT manpower and equipment available on the island and not change the A&E's design.

- Crawler Crane with Additional Bents
- Direct Pile Driving from Work Barge
- Jack-up AMMI Pontoon
- Construction Jacket
- Semi-Submersible Templet

After preliminary assessment of the above concepts, the construction jacket was recommended as the potential candidate. LT Wong, with concurrence of CDR Donovan, requested FPO-1 to pursue the cost estimate and design completion schedule for this candidate concept.

In November 1978, PACDIV requested an assessment of a commercially available FLEXIFLOAT ASSEMBLAGE for possible application. It was then found that the maximum length of the elevating spud columns with lift lugs is 50 feet which can only operate at about 33 feet water depth. The prescribed water depth at the mooring island site is 60 feet which is too deep to operate the flexifloat assemblage.

1.2 Objectives

The main objective of this report is to compile the FPO-1 efforts for the Diego Garcia POL Pier mooring island installation concept development. The documents and engineering drawings gathered during the course of concept study will provide needed information for future workload development in this area.

2. MOORING ISLAND INSTALLATION CONCEPTS

2.1 Concept No. 1 -- Crawler Crane with Additional Bents

This concept utilizes the existing pile-driving technique and procedures as those for the trestle and main pier. The advantages of this concept are:

- Seabees are familiar with the construction technique and procedures
- Proven success of pile-driving

The disadvantages are:

- Required more steel pipe piles for the additional bents
- Crawler cranes may be trapped in the mooring island during the construction period.

2.2 <u>Concept No. 2</u> -- Direct Pile-Driving from Work Barge

The prerequisites for the application of this concept are:

- Extremely calm sea
- Rigidly moored work barge

Pictorial presentations of the pile driving procedures are shown in figures 2.1 to 2.3. A pile-driven supporting truss is installed on the barge deck as shown in figure 2.1. Vertical piles are then driven to grade.

A reclaimable seafloor mat shown in figure 2.2 is clamped to the vertical piles as the position keeping guide for the batter piles at the mud-line level. The pile-driver lead is then leaned on the slope of the supporting truss, as shown in figure 2.3, for driving batter piles.

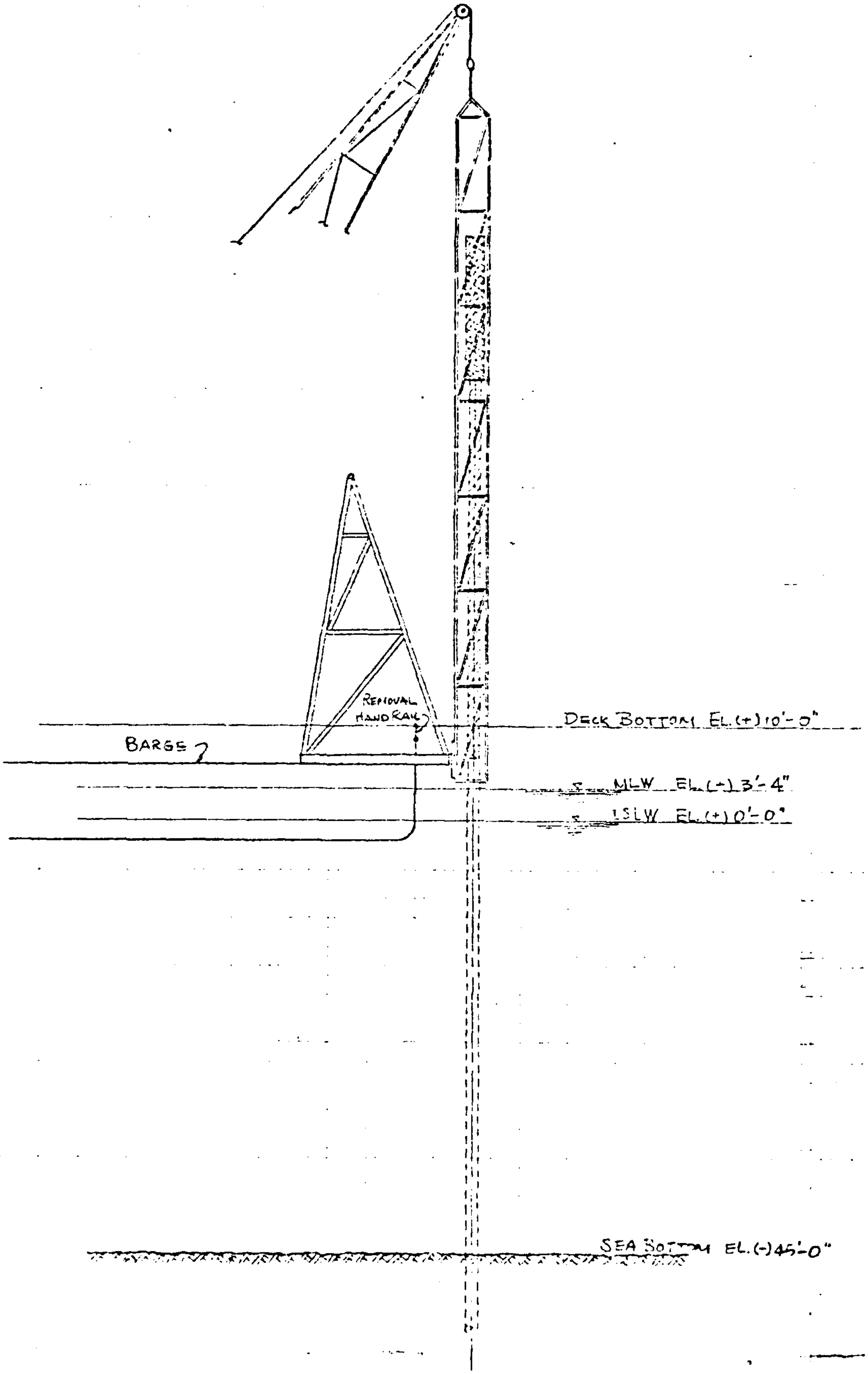


Figure 2.1 Barge Driving Scheme -- Vertical Pile with Pile Driver Support

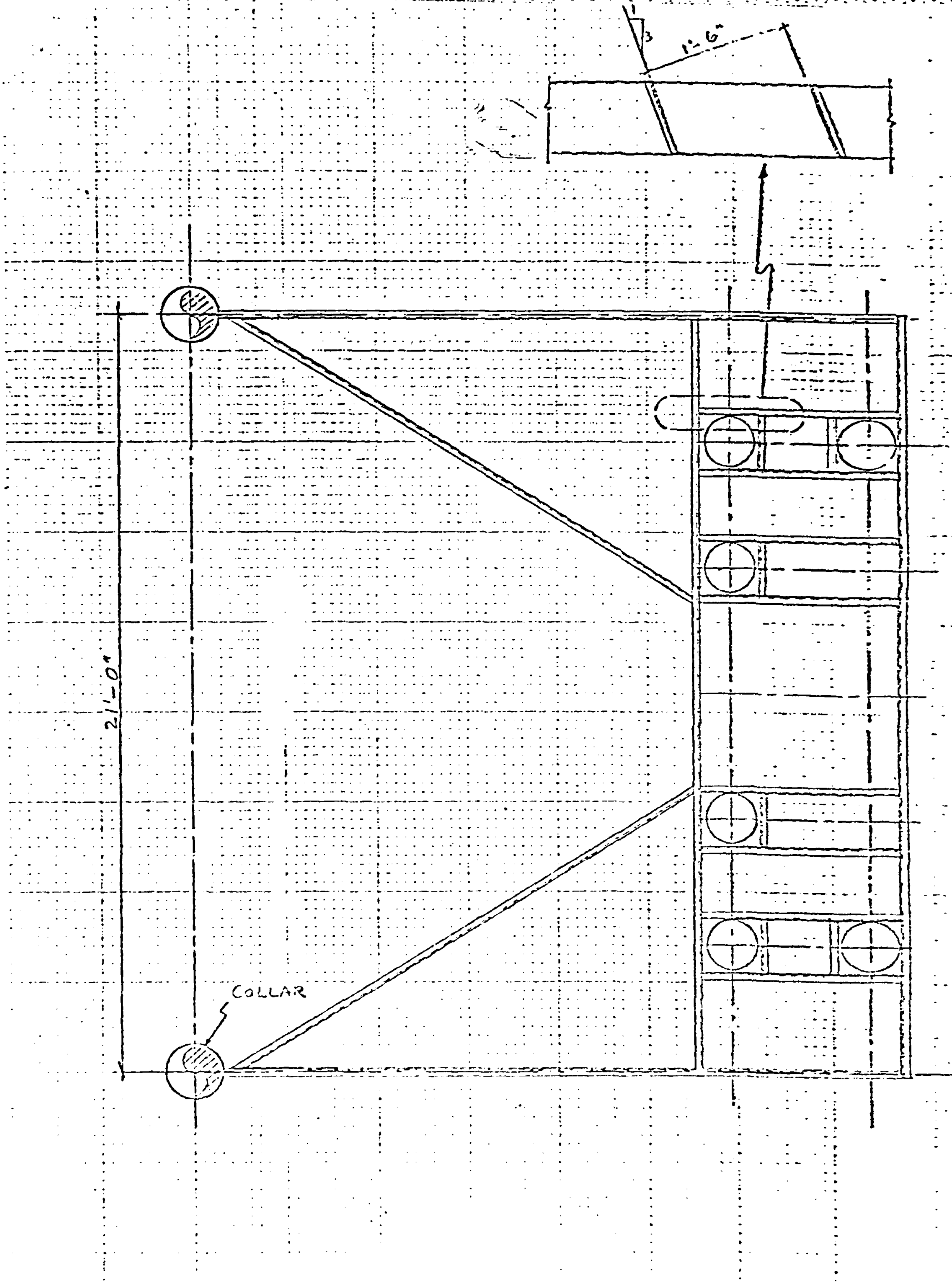


Figure 2.2 Seafloor Mat

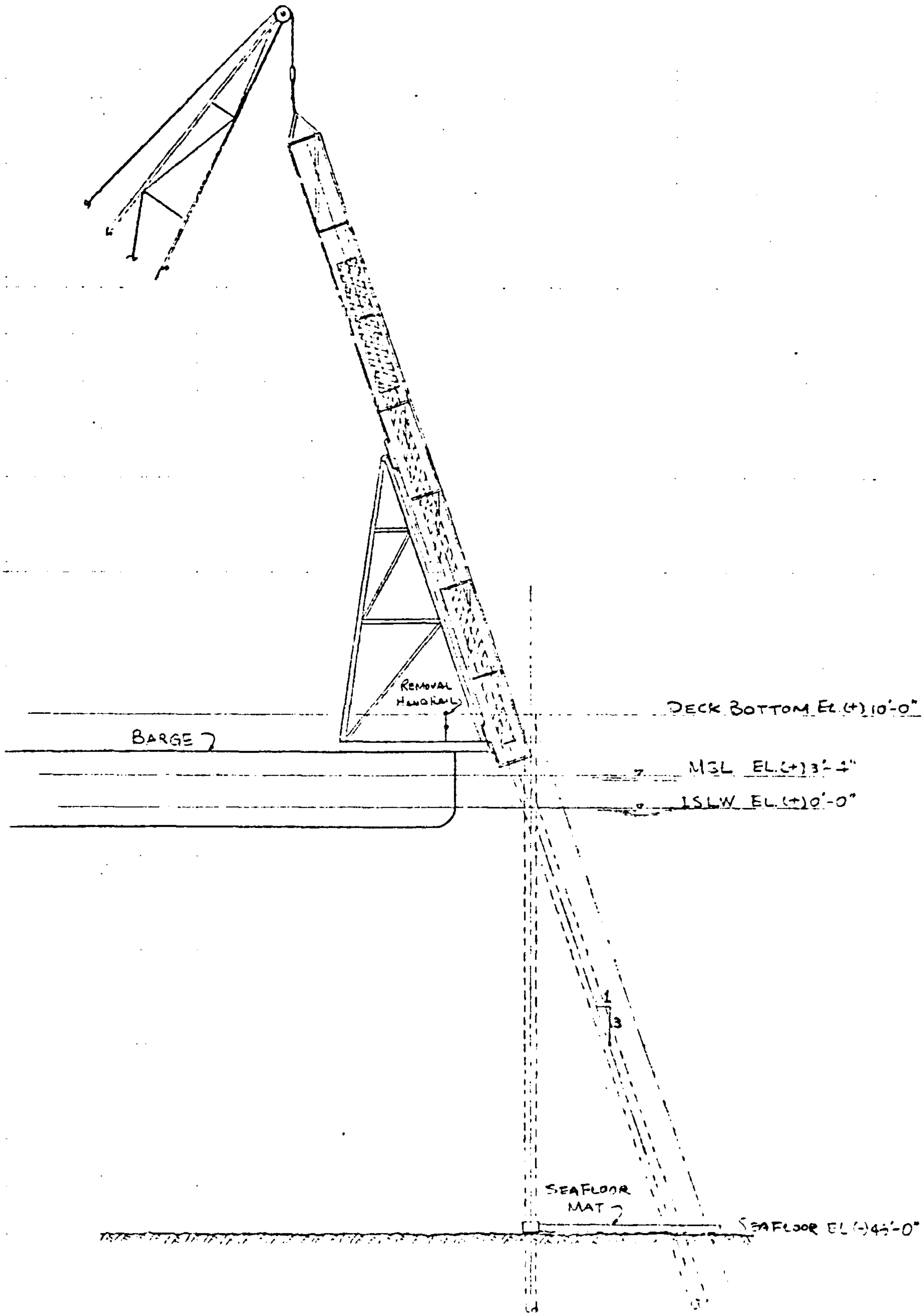


Figure 2.3 Barge Driving Scheme -- Batter Pile with Pile Driver Support

2.3 Concept No. 3 -- Jack-Up AMMI Pontoon

Figure 2.4 is the AMMI Pontoon in a jack-up mode (obtained from reference 1). The pontoon possesses the following characteristics:

- Dimension: 90 ft x 28 ft x 5 ft
- Displacement:

  Nominal 50 Short Tons @ 8 inches draft

  Nominal 290 Short Tons @ 50 inches draft
- Structural Members:

  Shell and Bulkhead 1/4 inch plate

  Framing Members 3/16 inch plate
  (Separated, bent and
  welded to shell and
  bulkhead)
- Design Deck Load: 600 psf
- Supporting Piles: 4 to 6 piles at 20 inches outside diameter

In order to evaluate the practical applicability of the jack-up AMMI pontoon at the mooring island sites, the weight items and the required supporting pile penetration are computed. It is noted that the following contributions are provided by Mr. David Raecke (FPO-1).

Weight Item

AMMI Pontoon	105,000 lbs
Crane, 50 ton mobile	72,000
Hammer, MKT DE 30	10,000
Lead	5,000
Batter Lead	18,500
Winches (2)	60,000
Pile Section (90 ft)	5,300
SUBTOTAL	275,800 lbs
5% for incidentals	13,790
Total weight to be lifted	289,590 lbs

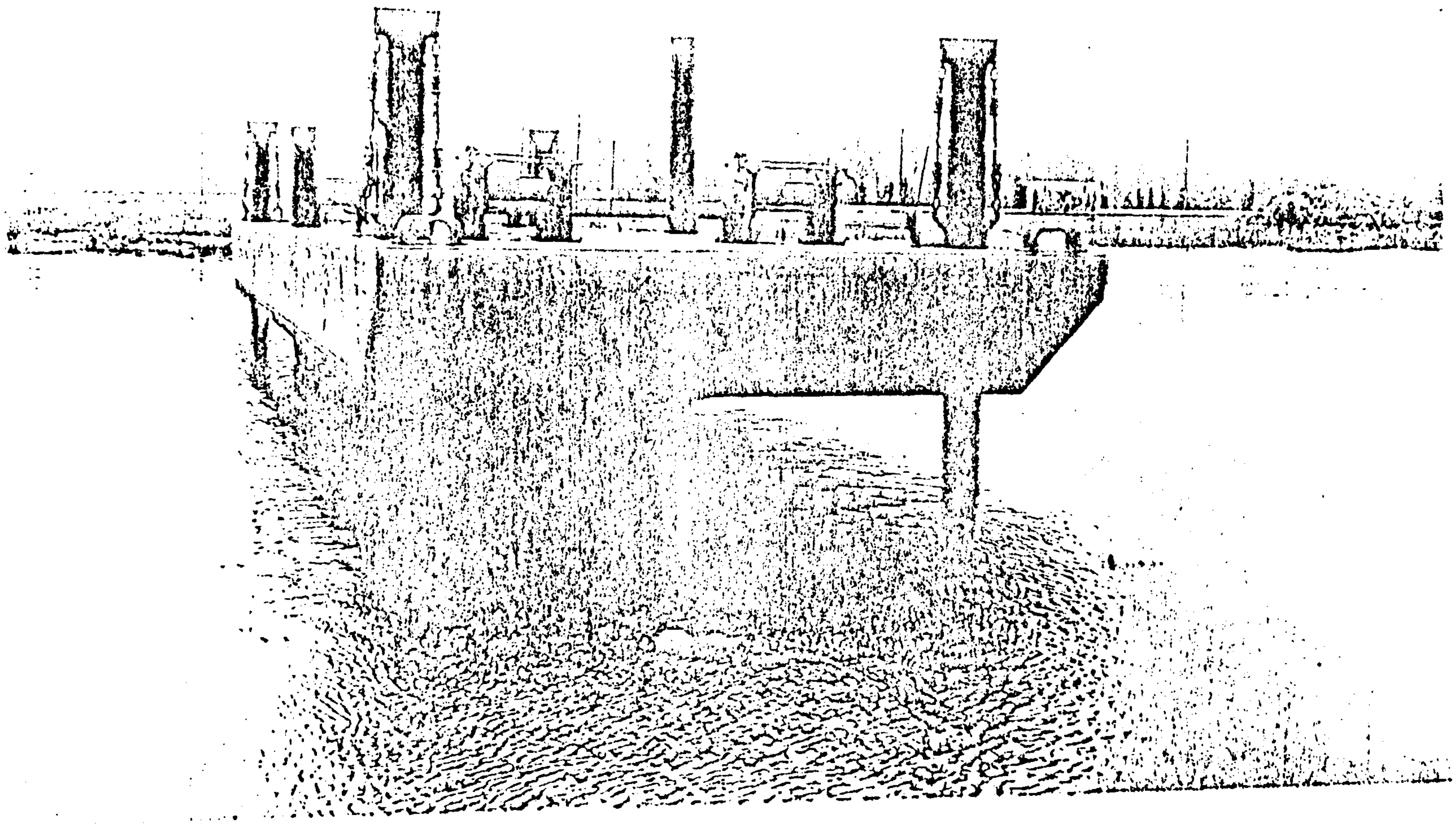


Figure 2.4 AMMI Pontoon at Jack-Up Mode

Pile Penetration Requirement

Friction area of a 20" Ø pile

$$\frac{20\pi}{12} = 5.24 \text{ sq. ft/ft of penetration}$$

Assuming that the average of 200 psf of skin friction between soil and pile steel surface is available, the pile penetration resistance is:

$$= 5.24 \times 200$$

$$\doteq 1{,}000 \text{ lbs/ft of penetration}$$

The penetration requirement, L, is

$$L = \frac{289{,}590}{6 \times 1{,}000} = 48.3 \text{ ft}$$

An alternative way of determining the pile penetration requirement can be obtained by the following expressions:

$$f = \bar{\sigma}_v K \tan \delta \qquad (1)$$

and

$$\bar{\sigma}_v = \gamma' D \qquad (2)$$

where
- f = skin friction between soil and pile steel surface
- $\bar{\sigma}_v$ = vertical effective stress in soil
- k = earth pressure coefficient relating vertical to lateral stress, use 0.7 in this case
- δ = angle of friction between soil and pile steel surface, estimated 20^o for silt and calcareous sand
- γ' = submerged unit weight of soil, 30#/cu. ft
- D = depth of soil above point where f is calculated

Combining Eqs (1) and (2), following expression is obtained:

$$D = \frac{f}{\gamma' \, k \tan \delta} \qquad (3)$$

If the average skin friction, f, is to be 200 psf, the pile penetration at mid-point (where the average f is computed) is

$$D_{ave} = \frac{200}{(30)\ (0.7)\ \tan 20^{o}} = 26.2 \text{ ft}$$

The total pile penetration is then

$$D = 2 \times D_{ave} = 52.4 \text{ ft.}$$

Findings

- The total pile length required:

Penetration below mud-line	50 ft
Water Depth	50
Air Gap	10
AMMI Pontoon Hull Depth	5
Above Hull Section	10
TOTAL	125 ft

- The normal AMMI elevating system does not permit easy welding of add-ons if the required pile length is greater than 40 feet.

- Penetrations may greatly exceed those estimated above depending on the depth of dredge spoil and other weak soils.

2.4 Concept No. 4 -- Construction Jacket

The construction jacket concept considers the following factors:

- The first section of the vertical pile and driving hammer will stand alone by itself under the working conditions of:
  - 3 feet wave
  - 10 knots wind
- Maximum list angle of 10^{o}
- Minimum crane barge mooring operation
- Safe operation

Figure 2.5 shows the elevation and the plans of the conceptual construction jacket.

Installation Procedures

The following steps are suggested in carrying out the mooring island pile driving:

(1) Install construction jacket

(2) Install welder's temporary work platform (for welding vertical piles only)

(3) Drive vertical piles (a total of 13 piles)

(4) Remove welder's temporary work platform

(5) Remove construction jacket (optional)

(6) Install work skid on top of vertical piles (design of work skid would not be included in this report)

(7) Install batter-pile-driving-support

(8) Drive batter piles (a total of 16 piles)

(9) Remove batter-pile -driving-support

(10) Remove work skid

(11) Proceed with concrete deck work

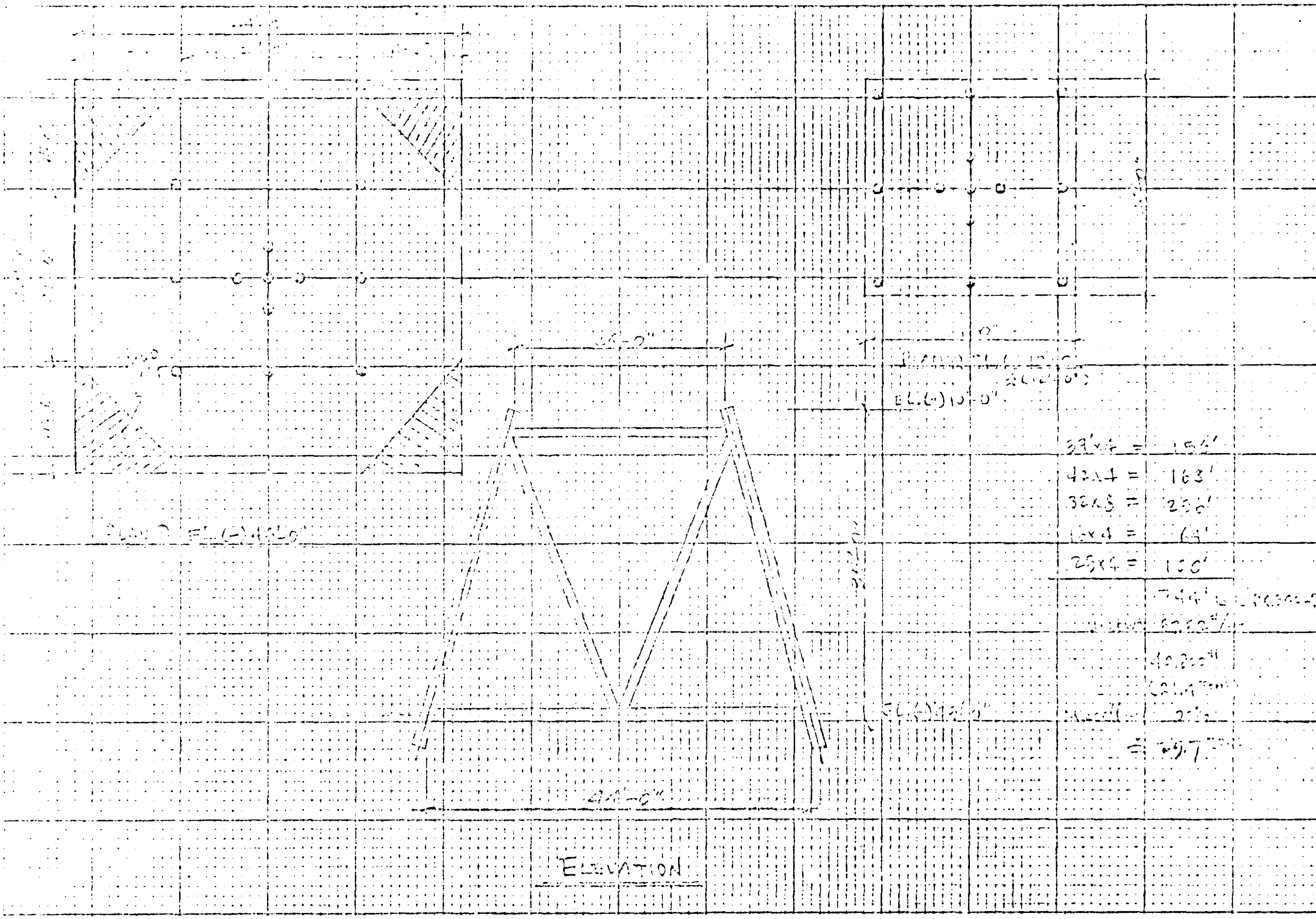


Figure 2.5 Plans & Elevation -- Construction Jacket

Backup Data

Computations of the overturning moment and the resisting moment of the system are described briefly herein. The overturning moment consists of the moment components caused by the gravity load, crane boom imposed horizontal force and environmental forces. The force components are illustrated in Figure 2.6.

Gravity Load:

Hammer Weight		9,000#
Drive Cap		1,150
Flying Lead		4,550
	TOTAL	14,700#

Pile weight (16"Ø x.344" WT)

95 ft x 57.52 #/ft = 5,464#

Moment M_1 = (14,700 x (95+7.5) + 5,464 x 47.5) Sin 10°

= 306,713 ft-lbs

Horizontal Force: Assuming that the unexpected crane boom imposed horizontal force is 500 lbs.

Moment M_2 = 500 x 110

= 55,000 ft-lbs

Environmental Forces:

Wind Velocity @ 10 knots = 11.5 MPH

Wind Area = 10 sq. ft (estimated)

Wind Force = $0.000256\ C_s V^2 A$ (ref 2)

= $0.00256 \times 1.0 \times (11.5)^2 \times 10$

= 3.4 lbs

Moment M_3 = 3.4 x 80

= 272 ft-lbs

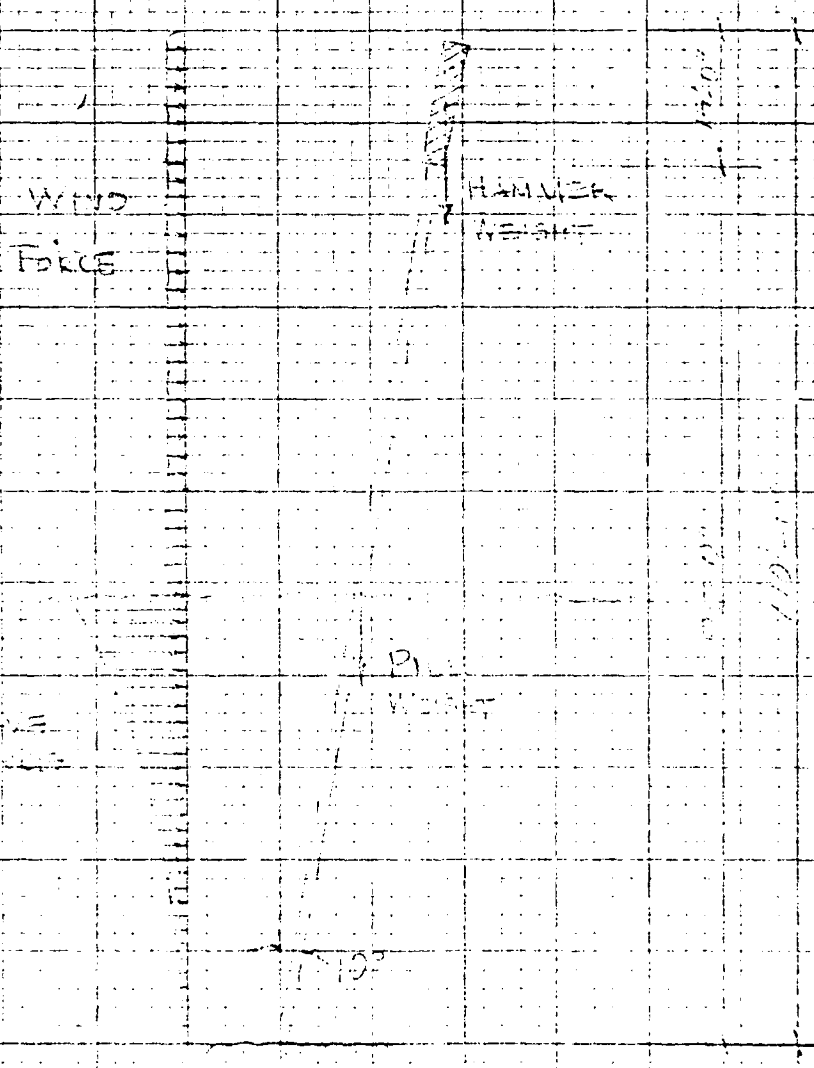


Figure 2.6 Force Components on a Vertical Pile

Wave: Height $H = 3$ ft

Period $T = 5$ sec.

Water Depth $h = 45$ ft MLW*

Pipe Diameter $D = 16''$ Ø

Drag Coefficient $C_D = 0.75$

Inertia Coefficient $C_M = 1.5$

According to the method presented in reference 3, the following parameters are computed:

$$\text{Wave length at deep sea, } L_o = gT^2/2\pi$$

$$= \frac{32.2 \times 5^2}{2\pi}$$

$$= 128 \text{ ft}$$

$$h/L_o = 45/128 = 0.351$$

$$H/L_o = 3/128 = 0.0234$$

$$\frac{C_D \rho D \, (H/T)^2 \, h^2}{2} = \frac{0.75 \times 1.99 \times \frac{16}{12} \left(\frac{3}{5}\right)^2 \times 45^2}{2}$$

$$= 725 \text{ ft - \#} \quad \text{(Drag Normalizing Moment)}$$

$$\frac{C_M \rho \pi D^2 \, (H/T^2) \, h^2}{4} = \frac{1.5 \times 1.99 \times \pi \times \left(\frac{16}{12}\right)^2 \times (3/5^2) \times 45^2}{4}$$

$$= 1{,}013 \text{ ft - \#} \quad \text{(Inertia Normalizing Moment)}$$

According to Case 7A in reference 3, the moment at mud-line as a function of wave phase angle are tabulated below:

---

*Initial data and charts indicated 45 ft MLW. This figure used during concept study. November 1978 diver survey reported 60 foot water depths.

Phase	0°	10°	20°	30°	50°	75°
M_D'	4.801	4.612	4.080	3.307	1.577	.180
M_D(ft-kips)	3.48	3.34	3.00	2.40	1.14	0.13
M_I'	0	1.876	3.629	5.155	7.271	8.055
M_I'(ft-kips)	0	1.90	3.68	5.22	7.36	8.16
M_T(ft-kips)	3.48	5.24	6.68	7.62	8.50	8.29

Where $M_D = M_D' \times 725$ ft - # (Drag Moment)

$M_I = M_I' \times 1{,}013$ ft - # (Inertia Moment)

and M_D' and M_I' are the dimensionless drag moment and inertia moment components, respectively.

The moment due to wave force contribution is:

$$M_4 = 8{,}500 \text{ ft - \#}$$

The total overturning moment is the sum of the above individual contributions, that is

$$M_{Total} = M_1 + M_2 + M_3 + M_4$$

$$= 306{,}713 + 55{,}000 + 272 + 8{,}500$$

$$= 370{,}485 \text{ ft-lbs}$$

The resisting moment is contributed by the gravity weight of the construction jacket. Assuming that the jacket weight 25 tons (19.5 tons in water) and that the base is 44 ft by 44 ft, the resisting amount is:

$$M_R = (19.5) \times 2{,}000 \times 22$$

$$= 858{,}000 \text{ ft-lbs}$$

In order to develop the above resisting moment, the soil pressure at the jacket base shall be less than the allowable soil bearing pressure at the mooring island site. Due to the lack of available soil data, an estimate of 1 psi soil bearing capacity is assumed. The bearing area required at the jacket base is then:

$$4A = \frac{19.5 \times 2{,}000}{1 \times 144}$$

$$= 270.8 \text{ sq. ft.}$$

$$A = 67.7 \text{ sq. ft at each corner}$$

The factor of safety of the system is:

$$F.S. = \frac{858{,}000}{370{,}485} = 2.32$$

2.5 Concept No. 5 -- Semi-Submersible Templet

The main function of the templet in this concept is to indicate the vertical pile location only. The templet does not possess any stabilizing effects to the positioning of the vertical pile prior to or during the pile-driving process. The procedures of installing the system are described briefly as follows:

(1) Drive the first section of the first vertical pile by all means, as shown in figure 2-7.

(2) Install welder's temporary work platform to the first pile section.

(3) Weld the first add-on section

(4) Remove welder's temporary work platform

(5) Drive the pile

(6) Repeat steps (2) to (5) for each add-on section

(7) Anchor the semi-submersible templet to the first vertical pile at EL.(-) 10'-0" level and also tie to the seafloor, shown in figures 2.8 and 2.9.

(8) Drive all other vertical piles

(9) Remove semi-submersible templet (optional)

(10) Set-up work skid on top of vertical piles

(11) Install batter-pile-driving-support

(12) Drive batter piles (a total of 16 piles)

(13) Remove batter-pile-driving-support

(14) Remove work skid

(15) Proceed with concrete deck work

It is noted that steps (10) to (15) are similar to those required in the previous concept.

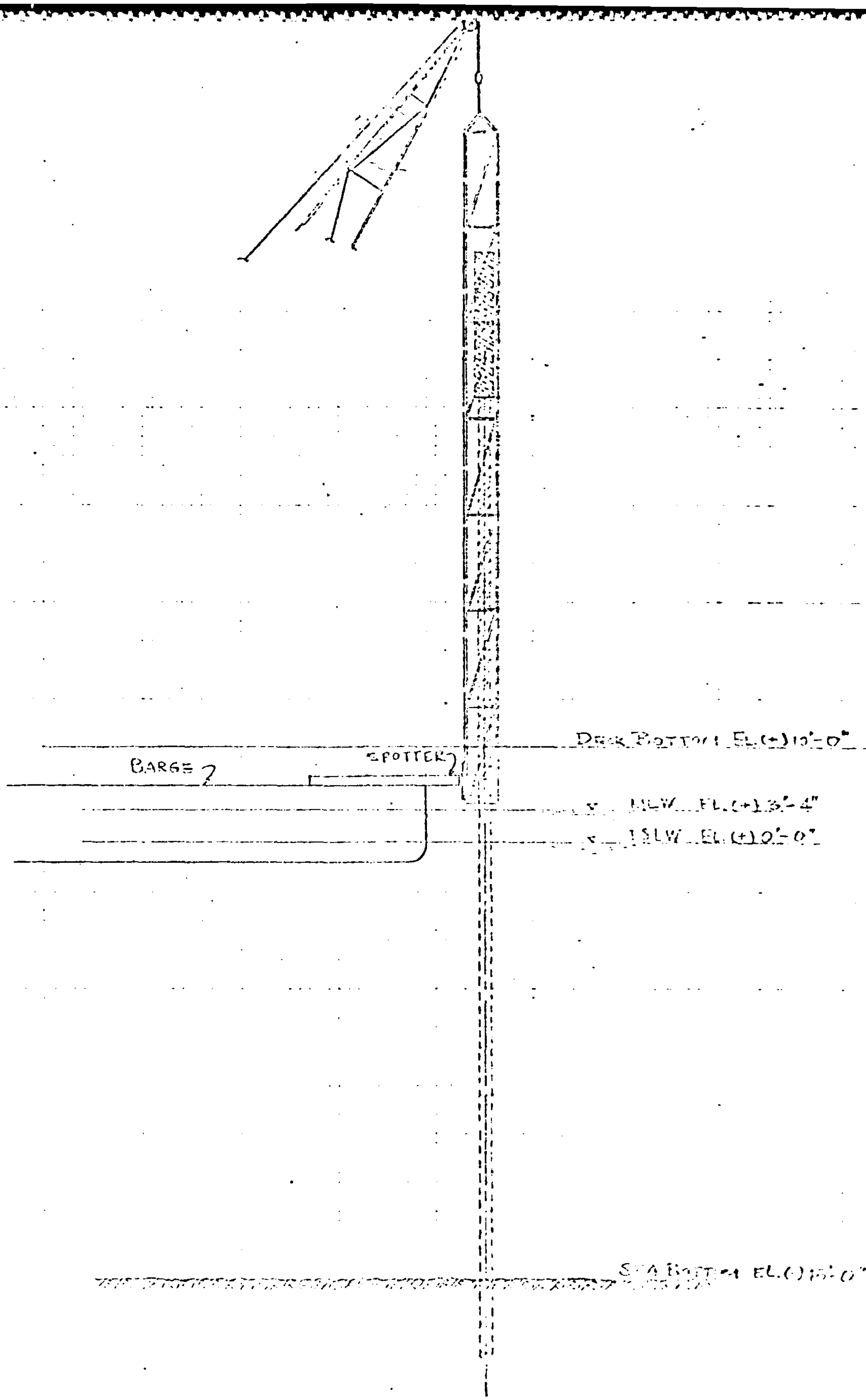


Figure 2.7 Barge Driving Scheme -- V rtical Pile without Pile Driver Support

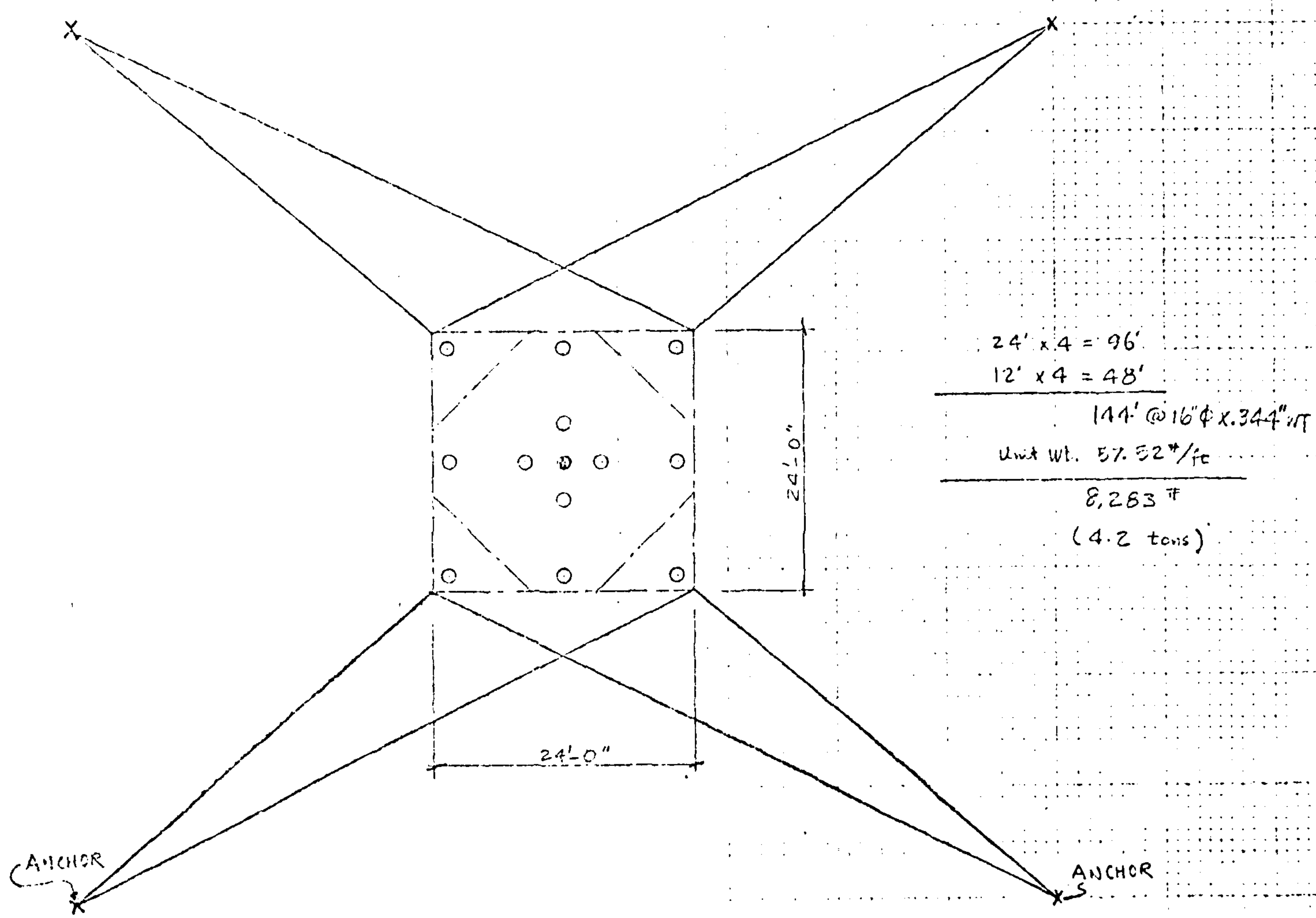


Figure 2.8 Plan -- Semi-Submersible Templet

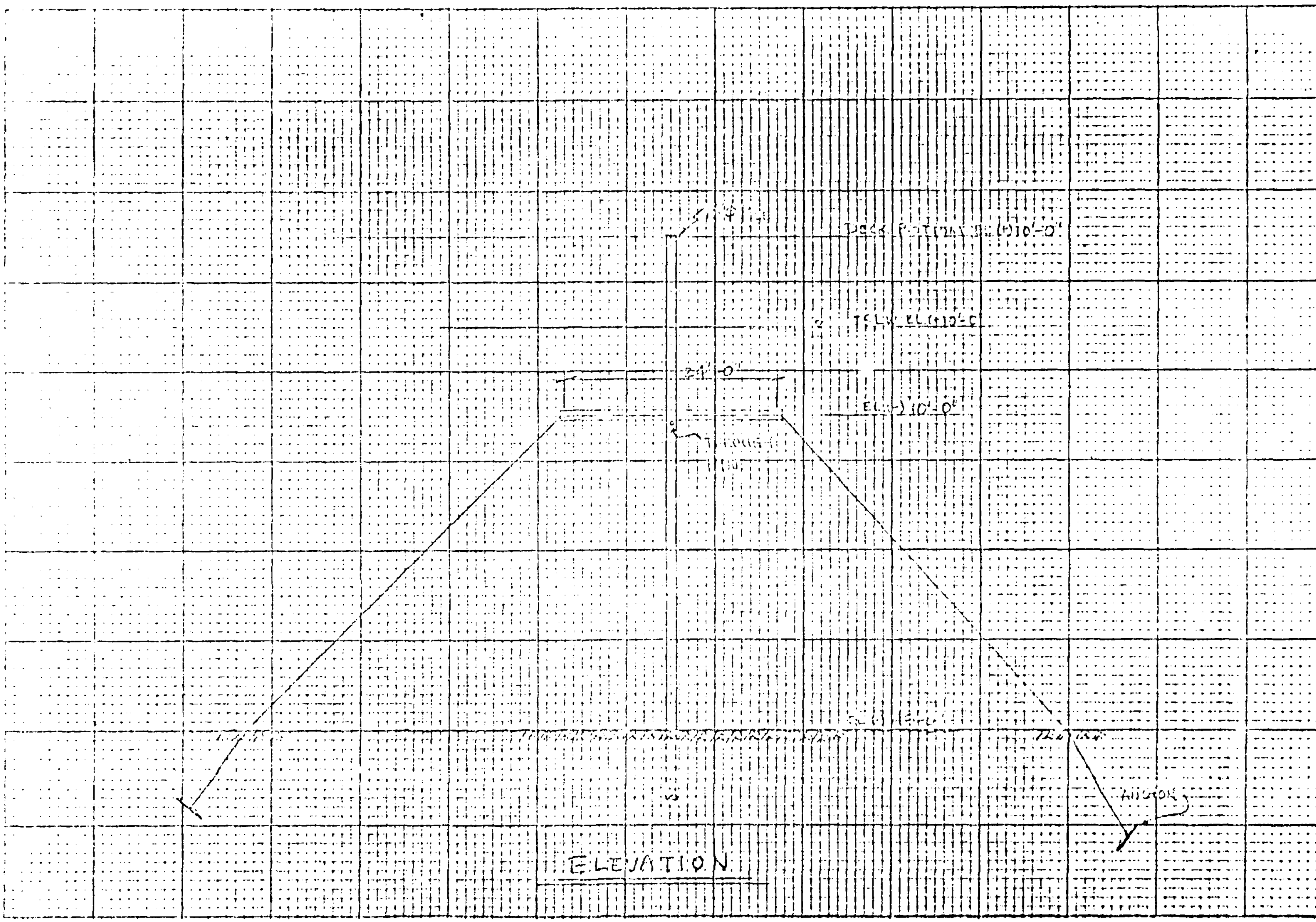


Figure 2.9 Elevation -- Semi-Submersible Templet

Backup Data

The computation herein is based on the following assumptions:

- The center pile is driven by any practical technique
- The semi-submersible templet is pinned to the center pile at EL (-) 10'-0" (35 feet above the seafloor)
- The templet is anchored to the seafloor by at least 4 cables similar to the configuration shown in figures 2.8 and 2.9.

CASE 1: Slack Cables -- Center Pile as Cantilever Beam

If the cables are slack, the overturning moment induced by the second pile at the initial state (see figure 2.6 and its force computations) will be resisted by the bending strength of the center pile at mud-line level. The force components are shown in figure 2.10a.

According to the computation in the previous section, the overturning moment of a vertical pile at the initial state is:

$$M_{total} = 365{,}985 \text{ ft-lbs}$$

The resisting moment of a 16"ØX.344" wt steel pipe pile is

$$M_R = S\,\sigma_b$$

where $S = 64.85 \text{ in}^3$

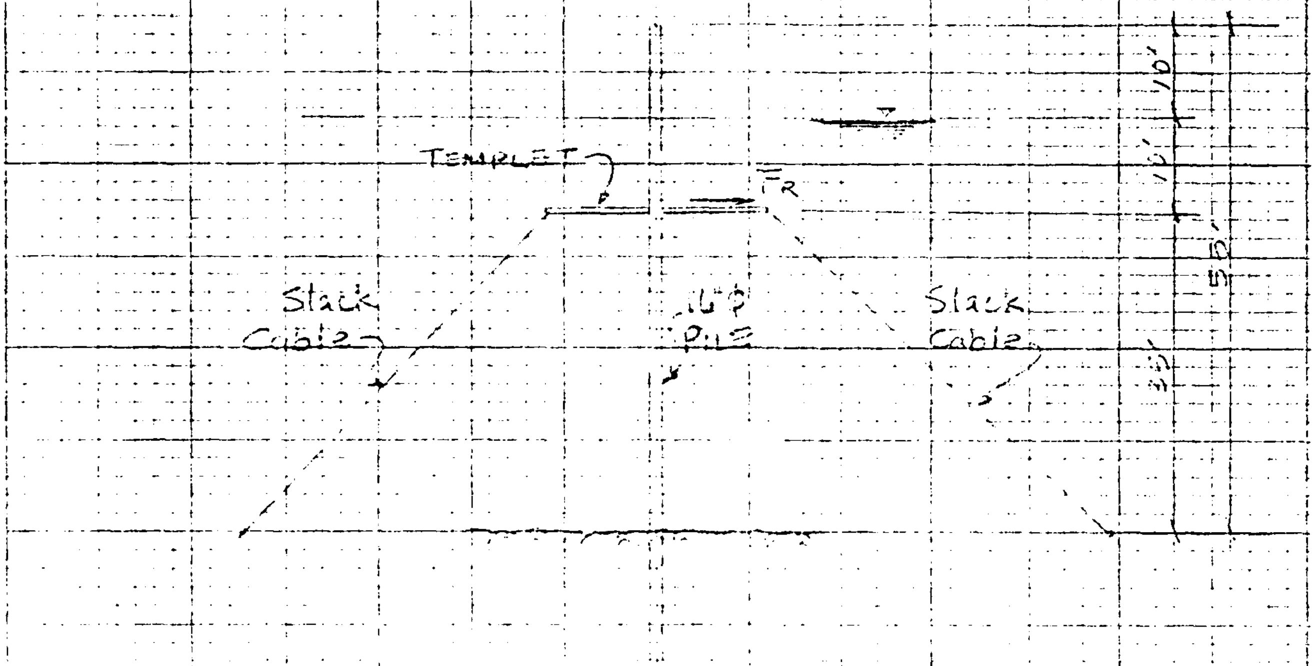
σ_b = 16 ksi (estimated allowable bending stress for 16"Ø pipe at S.F. = 1.65)

$$M_R = 64.85 \times 16 = 1{,}038 \text{ in-kips}$$

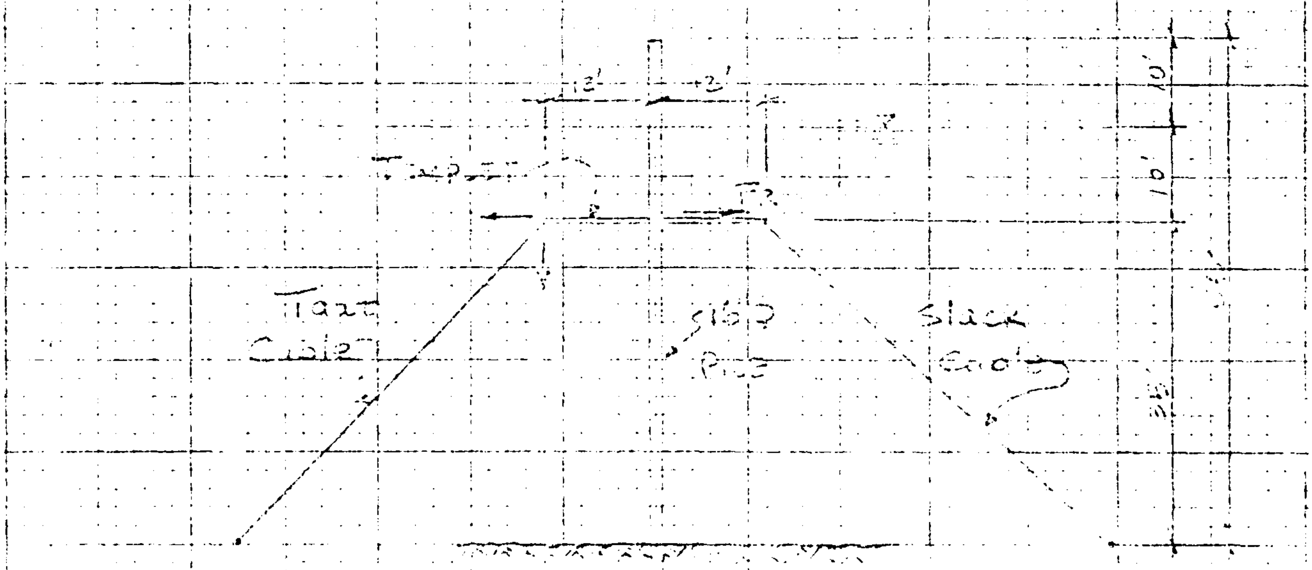
The factor of safety is:

$$S.F. = \frac{(1{,}038 \times 1{,}000) \times 1.65}{365{,}935 \times 12}$$

$$= 0.39$$



(a) Slack Cable Configuration



(b) Taut Cable Condition

Figure 2.10 Force Components on Semi-Submersible Templet

If the factor of safety of 2.0 is required in the system, the number of piles required is:

$$N = \frac{2.0}{0.39} = 5.12 \qquad \text{Say 5 piles}$$

CASE 2: Taut Cables -- Center Pile as Compression Post

If the cables are taut by pretensioning, the center pile will behave as a compression post. When a horizontal force is applied at the templet level, the force will produce a uniform bending moment to the center pile. Figure 2.10b shows the force components of the system. In the figure, pre-tensioning force components are omitted because symmetrical cable forces produce only compressive reaction in the center pile.

The overturning moment of the second pile at the initial state is:

$$M_R = 365{,}985 \text{ ft-lbs}$$

The resisting force at the templet level is:

$$F_R = \frac{365{,}985}{35}$$

$$= 10{,}467 \text{ lbs}$$

The induced moment on the center pile is:

$$M_{ind} = 10{,}467 \times 12$$

$$= 125{,}604 \text{ ft-lbs}$$

The factor of safety of the system is:

$$S.F. = \frac{(1038 \times 1{,}000) \times 1.65}{125{,}604 \times 12}$$

$$= 1.14$$

The number of piles required to obtain a factor of safety of 2.0 is:

$$N = \frac{2.0}{1.14} = 1.75 \qquad \text{Say 2 piles}$$

2.6 Concept No. 6 -- Flexifloats

Flexifloats are commercially available, standardized watertight, welded steel buoyant units. The floating work platform is constructed by interconnecting adjacent units into usable shapes having adequate buoyancy, strength and stability characteristics for supporting weights of material and mobile equipment imposed on the platform. In the open water environment, the assemblies of flexifloats with multipurpose attachments can be elevated above the tide and wave action for workover operations. Figure 2.11 illustrates the elevated mode of the flexifloat assemblage.

In November 1978, PACDIV requested an assessment of the applicability of the flexifloats for this project. Mr. Bodey (FPO-1) discussed the potential use of the flexifloats with Mr. Robishaw of Robishaw Engineering, Inc. The following information was the summary of this discussion:

- Flexifloat pontoons are available in two series:

  Series 70 10'x40'x7'

  Series 60 10'x20'x7'

- 36-inch diameter spud legs at 120 feet long are available from the Company base in the U.S. 48-inch diameter spuds are available from Holland.
- 16 feet length of the spuds are used up within jacks. With 10 feet air gap and 60 feet water depth on site, the maximum available column penetration is 34 feet.
- Shear carrying capacity per column is estimated at 140 tons.
- Estimated cost of the above flexifloat system will be $1,244/day for the first 30 days after which the rate will drop to $622/day.

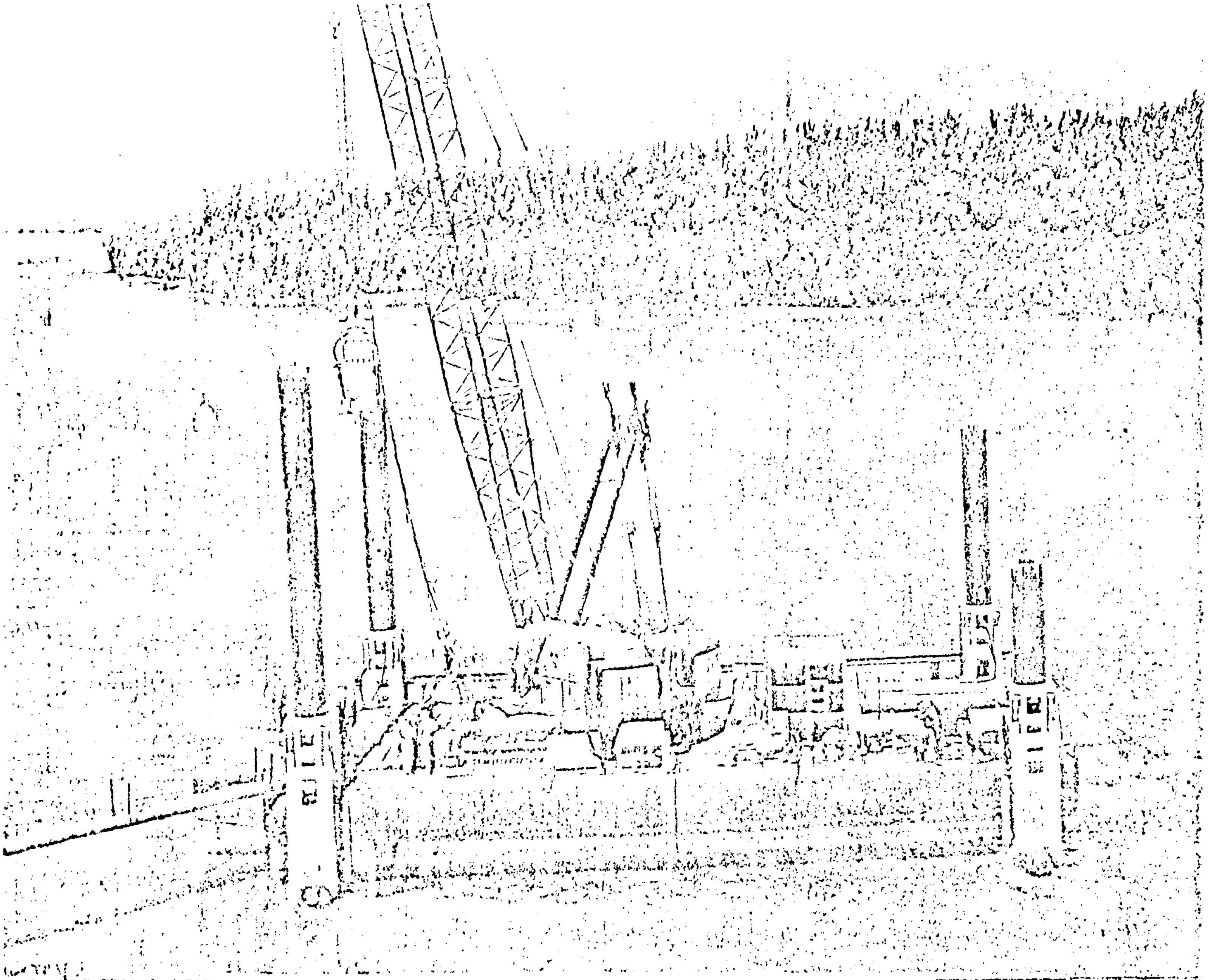


Figure 2.11 Flexifloat Assemblage at Elevated Mode

- Bearing Pads for spud legs are about 8 to 10 feet in diameter. At present, bearing pads are not available for 36-inch diameter spuds.
- Pontoons have only 2 flood valves on the upper deck and not possible to use pontoons as a jack-up mat.

Basing upon the above information and engineering judgement, CDR Donovan was advised that:

- Four 36-inch diameter legs are not sufficient to support work platform reliably on coral seafloor.
- 8 to 10 foot diameter spread pads are not available for 36-inch diameter legs and these are still not big enough for 350 psf foundation bearing capacity.
- Using two extra pontoons for jack-up mats is not feasible with present pontoons valving system.

In conclusion, the flexifloats is not a viable substitute for a real multi-leg jack-up platform. Finally, Mr. Bodey suggested to CDR Donovan to check at Singapore for cost and availability of a suitable offshore rig.

3. SCHEDULE AND COST ESTIMATE

3.1 Schedule

A tentative project schedule is shown in Chart 3.1. The schedule is planned for the design of construction jackets. The fabrication, transportation and installation timetables are not included.

3.2 Cost Estimate

3.2.1 Engineering and Construction Support

3.2.1.1 Pile-Jacket Concept/Plan/Proposal

• Requirements Acquisition (60 hours)	$1,290
• Develop/Select concept from 3-5 schemes with report (180 hours)	3,810
• Preliminary Plan and Cost Estimates (40 hours)	845
• Fonecon Proposal (4 hours) (Include Lt. Jerry Wong meetings)	86
	$6,031

3.2.1.2 Resource/Capabilities/Environmental Data Acquisition *

- Trip to Diego Garcia: labor, travel and perdiem for 14 total days

Travel (via San Francisco)	$2,700
Labor 12 days (96 hours)	2,064
Perdiem	90
D.G. @ $17/day	204
	$5,058

* LCDR Pete Marshall of UCT 2 performed this task in November 1978.

PROBABLE EARLIEST/LATEST COMPLETION DATE

Mooring Dolphin Installation, Diego Garcia

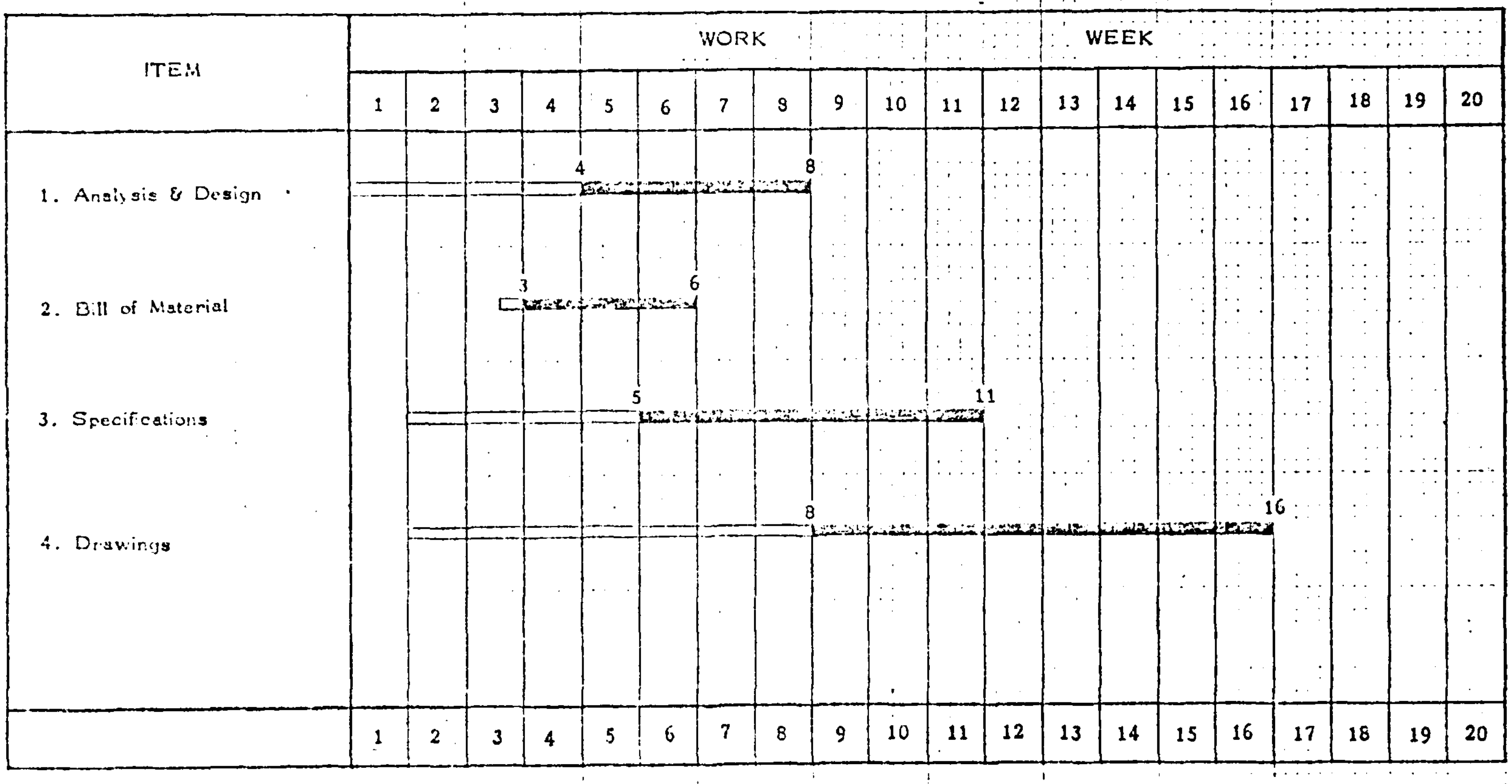


Chart 3.1 Construction Jacket Design Completion Schedule

3.2.1.3 Engineering Analyses and Design

• System Analysis: loads, stresses, design interface definition (with A&E falsework, environment, equipment), erection and handling loads, etc: 80 hours	$ 1,720
• Jacket design (load-out, dwgs, spec call-outs, Bill of Materials: 480 hours	10,320
• Vert. pile add on splice sleeve and assy dwg(s): 40 hours	860
• Rail and Falsework System Modifications (Jacket interface mods, vertical pile guide mods, jacket and pile grouting call-outs: A&E Sepias with corrections, addition and notes) 160 hours	3,440
	$16,340

3.2.1.4 Mooring Plan and Installation (Based on assumed support by CEL)

• Mooring design analyses for crane barge (one mooring per dolphin). Plan with recommended rigging hardware: 160 hours	3,440
• Install embedment anchors - 2 sites Travel/labor/per diem (see 2.0 above)	5,058
• Anchors & explosives - 12 20K anchors @ $1500	18,000
	$26,498

3.2.1.5 Construction Supports

• Jacket fab & erection plan	
• Jacket floatation, upending, orientation and leveling plan	
• Falsework installation plan	
• Vertical pile stabbing, driving and add-on welding plan (scenarios, safety precautions, instructions, etc) 480 hours	10,320
• Field support: one man on site (4 weeks travel and field work)	
Travel	2,700
Labor hours (40+6x10x3 = 720 hrs)	3,870
	$16,390

3.2.1.6 Total engineering/construction supports	$70,817

3.2.2 Materials

The materials listed below are obtained from the preliminary design drawings as of January 1979. These drawings are:

NAVFAC DWG. NO.	TITLE
3017671	Title Sheet
3017672	General Assembly
3017673	Details, Deck Module
3017674	Details, Center Module
3017675	Details, Base Module
3017676	Details, Construction
3017677	Details, Construction
3017678	Details, Construction
3017622	Pile Splice Detail
3017623	Supporting False Work

The estimated material costs per jacket are tabulated below. The cost item does not include planned falsework, shipping, fabrication, weld rod, labor, fuel, etc.

ITEM	QUANTITY	UNIT COST	TOTAL COST
(a) Conventional Rolled Shapes and Pipes			
C8 x 11.5	15.18 tons		
20"Ø Sch. 20 STD	17.45		
L2x2x¼	.11		
1" plates	1.35		
¼" plates	0.89		
3/8" plates	2.13		
Subtotal	37.11	$500/ton*	$18,555
(b) Special Rolled Pipes			
Pile Splice	8.35	$1,00/ton**	8,350
(c) Rough Timber			
12x12 timber	310 L.F.	$10/L.F.	3,100
(d) Miscellaneous spikes, bolts, etc.			1,000
Total Material Cost per Jacket			$31,005

* Average mill price at Bethlehem Steel Corporation (Sep 1978)

** Estimated market price at west coast

3.2.3 Summary

Item		Cost
Jacket Materials		
2 @ $31,000 ea.		$62,000
Engineering/construction supports		$70,800
	TOTAL	$132,800

4. SUMMARY AND RECOMMENDATIONS

4.1 Summary

Summaries of the concept development for the installation of POL Pier mooring island at Diego Garcia, Chagos Archipelago, may be drawn as follows:

- The use of crawler crane with additional bents to reach the mooring island site may result in trapping the crane in the last construction bent. In addition, the amount of steel pipes needed as the construction bents may be uneconomical.

- Direct driving of all pilings from the barge will require a rigidly moored barge which appears to be an extremely difficult task at the construction site.

- Jack-up AMMI pontoon concept is site dependent. Without extensive modification of the current jacking system, the jack-up operation can not be applied to this approach.

- Construction jacket concept presents a safe operational procedure. The operating environment is designed for a 3 feet wave and 10 knots wind condition which is a common sea state at the construction site during May-July period. Under the design sea state, the system will have a factor

of safety of 2.5 at the initial stage of driving the first pile. However, the jacket weight (dead weight) of approximately 28 tons may cause some difficulties in weight handling process.

- Semi-submersible templet concept has the light weight advantage. However, the concept requires driving of at least 3 to 5 vertical piles to grade at high risk which is not commonly carried out in engineering practice.

4.2 Recommendations

The recommendations based on the results of this concept study are:

- the construction jacket concept possesses safe operational procedure for SEABEE to perform offshore pile driving. This concept shall serve as the base for further engineering development in conjunction with the mooring island installation assistance.

- an installation plan shall be proceeded to investigate practical methods of overcoming the weight handling difficulties of the construction jacket.

REFERENCES

1. AMMI Pontoon, A Naval Facilities Engineering Command Seabee Development, 1968.

2. Design of Steel Structures, by Gaylord and Gaylor, McGraw-Hill Book Company, 1972.

3. Evaluation and Development of Water Wave Theories for Engineering Application, Volume 1 and 2, U.S. Army Corps of Engineers, Coastal Engineering Research Center, 1974.

4. Container Off-loading & Transfer System (COTS), NAVFAC Program Element: PE 63719N, 1977

5. Reliability, Availability, and Maintainability (RAM) for the Elevated Causeway Facility of the Container Off-loading Transfer System (COTS), CEL TM 55-78-06, 1978

6. Container Off-loading and Transfer System (COTS) Advanced Development Tests of Elevated Causeway System, Volume I-Summary, CEL R 852-I, 1977

7. Container Off-loading and Transfer System (COTS) Advanced Development Tests of Elevated Causeway System, Volume II-Elevated Causeway Installation and Retrieval, CEL R 852-II, 1977

8. Container Off-loading and Transfer System (COTS) Advanced Development Tests of Elevated Causeway System, Volume III-Elevated Causeway Structure, CEL R 852-III, 1977

9. Container Off-loading and Transfer System (COTS) Advanced Development Tests of Elevated Causeway System, Volume IV-Fender System and Lighterage Motions, CEL R 852-IV, 1977

10. FLEXIFLOAT, Robishaw Engineering Inc., Houston, Texas (Catalog No. 8595).

APPENDICES

A.1 Documents and Drawings

The following documents and drawings are used in this report:

Documents

1. Report of Conceptual Design Recommendations for a Pier at Diego Garcia, B.I.O.T., prepared by Lyon Associates, Inc., February 1976.

2. Construction Equipment List at Diego Garcia, supplied by LT J.J. Wong.

Drawings

NAVFAC Dwg. No.	TITLE
7,013,333 to 7,013,339	Main Pier Civil
7,013,340 to 7,013,345	Architectural
7,013,346 to 7,013,395	Structural
7,013,396 to 7,013,398	Mechanical
7,013,399 to 7,013,403	Piping
7,013,404 to 7,013,417	Electrical

CONSTRUCTION SUPPORT

7,013,431	Isometric and Construction Sequence Structural-Mooring Island and Catwalk Pier Isometric
7,013,432	Isometric and Construction Sequence Structural-Mooring Island and Catwalk Pier Construction Sequence
7,013,440	Main Pier Structural-Construction Sequence at Main Pier
1,109,804	AMMI Pontoon Hoisting Arrangement

A.2 Correspondence

The following messages were compiled during the period of this concept study:

NNNNVZCZCHJA158
RTTUZYUW RHHMSGG0416 2380431-UUUU--RUEBJHA.
ZNR UUUUU
R 260417Z AUG 78 CHESDIV/1/
FM COMCBPAC PEARL HARBOR HI
TO RUWDPAA/COM THREE ONE NCR PORT HUENEME CA
RUCLBIA/COM TWO ZERO NCR GULFPORT MS
RUEBJHA/CHESNAVFACENGCOM WASHINGTON DC
INFO ZEN/PACNAVFACENGCOM PEARL HARBOR HI
RULYSDK/COMCBLANT NORFOLK VA
RUVNSAA/THREE ZERO NCR DET DIEGO GARCIA
BT
UNCLAS //N04650//
OIC SPECIAL PIER DET, DIEGO GARCIA
1. FOR 31ST NCR: LT J. WONG, OIC SPECIAL PIER DET, WILL ARRIVE LOS ANGELES 4 SEP 78 ON WA 562, ETA 1655. REQUEST 31ST NCR BE PREPARED TO DISCUSS FOL TOPICS WITH LT WONG ON 5 SEP.
A. HOMEPORT TRNG FOR RETURNING PIER DET MEMBERS.
B. ADMIN PROCEDURES RE PIER DET.
C. MATL SUPPORT STATUS FOR PIER PROJ
2. FOR 20TH NCR: LT WONG WILL ARRIVE GULFPORT ON SO 341, ETA 2228 ON 6 SEP 78. FOL TOPICS WILL BE DISCUSSED 7 SEP 78.
A. HOMEPORT TRNG FOR RETURNING PIER DET MEMBERS.

PAGE 02 RHHMSGG0416 UNCLAS
B. ADMIN PROCEDURES RE PIER DET.
C. ~~PERSONNEL REPLACEMENT PROCEDURES.~~
3. FOR CHESDIV: LT WONG WILL BE PREPARED TO DISCUSS FOLLOWING TOPICS ON 11 SEP 78:
A. DESIGN CONCEPTS FOR MOORING DOLPHIN TEMPLATE.
B. EQUIP AND MATL AVAILABILITY.
C. DRIVING BARGE MOORING REQMTS.
D. MOORING DOLPHIN CONSTRUCTION SEQUENCE.
BT
#0416

26 AUG 78 13:19

1
1A
ICP
1E

260417Z AUG 78/JB

44

NAVAL MESSAGE

OPNAV FORM 2110/26 (REV. 3-69) S/N-0107-LF-705-4001

RELEASED BY	DRAFTED BY	PHONE EXT NR	PAGE	PAGES
J. A. [illegible]	LT J. J. [illegible]	[illegible]	1	OF 1

DATE	TOR/TOD	ROUTED BY	CHECKED BY
13 Sep 1973			

MESSAGE NR	DATE/TIME GROUP	PRECEDENCE	FLASH	IMMEDIATE	PRIORITY	ROUTINE
		ACTION			[illegible]	
		INFO			[illegible]	

FROM: CHESNAVFACENGCOM WASHINGTON DC

TO: 30 NCR DET DIEGO GARCIA

INFO: PACNAVFACENGCOM MAKALAPA HI

COMCBPAC MAKALAPA HI

31 NCR PT HUENEME CA

UCT TWO PT HUENEME CA

UNCLAS //N11000//

PASS TO PIER TEAM

DG-831 PERMANENT PIER

1. IN SUPPORT OF DESIGN OF CONSTRUCTION SUPPORT EQUIPMENT FOR MOORING ISLANDS, REQ CONDUCT BOTTOM SURVEY OF MOORING ISLAND SITES. SURVEY AREA WITHIN 200 FT RADIUS FROM CENTER OF MOORING ISLAND. IDENTIFY AND LOCATE, I.E. APPROXIMATE BEARING AND DISTANCE FROM CENTER OF MOORING ISLAND, ALL OBSTRUCTIONS. DESCRIBE BOTTOM COMPOSITION, EG SOFT, LOOSE SAND OR CORAL HEADS. PROBE WITH 5 FOOT PIECE OF REBAR OR SIMILAR HAND HELD TOOL TO CHECK DEPTH AND [illegible] OF SEDIMENT.

2. INFORMATION REQUESTED IS REQUIRED IN ORDER TO PROCEED WITH DESIGN OF [illegible] CONSTRUCTION TEMPLATE FOR MOORING ISLANDS AND [illegible] DURING CONSTRUCTION PHASE. RECOGNIZING LIMITATIONS ON SITE, SURVEY [illegible] IS INTENDED TO BE A DIVER EVALUATION OF THE BOTTOM CONDITIONS TO IDENTIFY PHYSICAL CONDITIONS WHICH COULD AFFECT DESIGN WORKABILITY/FEASIBILITY. [illegible] OF SURVEY INFORMATION [illegible].

3. [illegible]

[illegible]

UNCLASSIFIED

NNNNVZCZCHJA327
RTTUZYUW RUHPSGG5366 2571303-UUUU--RUEBJHA.
ZNR UUUUU
R 141302Z SEP 78
FM THREE ZERO NCR DET DIEGO GARCIA
TO RUEBJHA/CHESNAVFACENGCOM WASHINGTON DC
INFO RHHMBRA/PACNAVFACENGCOM PEARL HARBOR HI
RHHMBRA/COMCBPAC PEARL HARBOR HI
RUWDPAA/COM THREE ONE NCR PORT HUENEME CA
RUWDPAA/UCT TWO
BT
UNCLAS //N00000//
PIER TEAM SENDS FOR LT WONG, OIC
DG-5-851 PERMANENT PIER
A. YOUR 131930Z SEP 78
1. SEA BOTTOM SURVEY WILL BE CONDUCTED IAW REF A. MOORING ISLAND LOCATIONS "SHOT-IN" EARLY THIS WEEK. ACTUAL SURVEY TO BEGIN THURSDAY/FRIDAY. SURVEY RESULTS WILL BE FORWARDED EARLIEST.
BT
#5366

ACTION
CHES-A
SEP 78 15 04 Z

141302Z SEP 78/GW

CODE	INITIAL	DATE
00		
09		√
09F		
FPO-1		√
01		
09A		
FPO-2		
09B		
09P		
0143 FILE		

NNNNVZCZCHJA006
RTTUZYUW RUHGSGG1483 2760550-UUUU--RUEBJHA.
ZNR UUUUU
R 030540Z OCT 78
FM THREE ZERO NCR DET DIEGO GARCIA
TO RUEBJHA/CHESNAVFACENGCOM WASHINGTON DC
INFO RHHMBRA/PACNAVFACENGCOM PEARL HARBOR HI
RHHMBRA/COMCBPAC PEARL HARBOR HI
RUWDPAA/COM THREE ONE NCR PORT HUENEME CA
RUWDPAA/UCT TWO
BT
UNCLAS //N11000//
DG5-851, PERMANENT PIER
A. YOUR 131930Z SEP 78

CHESDIV 5 FPO-1 1E Orgn 1A 0263 1CP Course

OCT 10 1978 13 Z

1. SURVEY REQUESTED REF (A) CONDUCTED BY DIVERS FROM UCT TWO. AVERAGE DEPTH AT SITE OF MOORING ISLANDS WAS SIXTY FEET. VISIBILITY AT BOTTOM WAS FIVE TO TEN FEET. BOTTOM SURVEY WAS MADE USING A PROBE AND 200 FT. SEARCHING LINE WHICH HAD BEEN MARKED OFF AT SIX FT. INTERVALS. NO MAJOR OBSTRUCTIONS WERE NOTED WITH THE EXCEPTION OF THE NORTH SITE. AT 100 FT. NORTH OF THIS SITE THERE IS A BANK WHICH APPARENTLY WAS CAUSED BY THE PASSAGE OF A DREDGE. THE DEPTH AT THIS AREA IS 40 FT. WITH A GRADUAL SLOPE. SILT WITH A DEPTH OF ONE FOOT UNDERLAIN BY A

HARD CORAL LAYER IS EVIDENT AT BOTH SITES. BOTH NORTH AND SOUTH SITES ARE STREWN WITH LARGE CHUNKS OF CORAL. CORAL BOULDERS WHICH AVERAGE 4 FT. IN DIA ARE RANDOMLY SPREAD OVER EACH SITE.
BT
#1483

030540Z OCT 78 SH

NNNNVZCZCHJA391
RTTUZFDY RUWDSGG2281 3080123 RUEB-UUUU--RUEBJHA.
RTTUZYUW RUWDSGG2281 3080123-UUUU--RUEBJHA.
ZNR UUUUU
R 040211Z NOV 78
FM UCT TWO
TO RUEBJHA/CHESNAVFACENGCOM WASHINGTON DC
INFO RHHMBRA/COMCBPAC PEARL HARBOR HI
ZEN/COM THREE ONE NCR PORT HUENEME CA
RUHJFBA/COM THREE ZERO NCR GUAM
RUVNSAA/THREE ZERO NCR DET DIEGO GARCIA
RHHMBRA/PACNAVFACENGCOM PEARL HARBOR HI
BT

CHESDIV(A)

UNCLAS //N11000//
DIEGO GARCIA MOORING DOLPHINS
A. DG SITE VISIT BY LCDR MARSHALL FO 21-27 OCT 78
B. FUTURE MTG LCDR STAMM AND LCDR MARSHALL 12-15 NOV 78
1. AS A RESULT OF REF A, FOLLOWING DATA PROVIDED:
A. NORTH AND SOUTH DOLPHIN SITES HAVE CIRCULAR AREAS APPROX 100 FT RADIUS WHICH ARE RELATIVELY LEVEL AT DEPTH 52 FT BELOW MLLW. TIDE RANGE APPROX EIGHT FT.
B. BOTTOM IS GENERALLY LEVEL BUT QUITE IRREGULAR DUE TO CORAL OUTCROPS AND LARGE CORAL CHUNKS. ENTIRE AREA BURIED UNDER ONE FOOT FINE SLIT. BOTTOM VISIBILITY LESS THAN TEN FT.

5 OCT 78 22:50 Z

C. ANTICIPATE LEVELING OF TEMPLATE TO BE MAJOR DIFFICULTY OF DOLPHIN INSTALLATION. REQUEST DESIGN EFFORT AND INSTALLATION SEQUENCE CONSIDER ADAPTING UP TO TWO FOOT VARIANCE ACROSS TEMPLATE FOOTING.
2. ADDL MINOR INFO AND PICTURES TO BE PROVIDED DURING REF B.
3. ALL FIELD CONST PERSONNEL ARE MOST ANXIOUS TO VIEW AND ANALYZE DOLPHIN DESIGN AT THE EARLIEST OPPORTUNITY. REQUEST CONTINUE TO KEEP US WORKERS INFOED ON PROGRESS AND DESIGN.
BT
#2281

Ø4Ø211Z NOV 78/JR

END
FILMED

6-86

DTIC